



Robotics Publications

ON THE LOOKOUT

The Air Mobile Ground Security and Surveillance System (AMGSSS) Has Arrived

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INTRODUCTION

The Air Mobile Ground Security and Surveillance (AMGSSS) project has the objective of developing a system that can rapidly position remotely operated ground sensors at locations of operational interest and provide information obtained by those sensors back to the operator. AMGSSS exploits the capabilities of small, remotely operated, vertical-take-off-and-landing (VTOL) ducted fan aircraft to provide mobility to the sensor payload. These platforms can be operated effectively over the low-bandwidth tactical radio data-links required by military users.

BACKGROUND

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Figure 1 Airborne Remote Observation Device

The AMGSSS concept grew from NRaD's experience with the Ground Air Telerobotic System (GATERS) program [1], initiated in 1986 by the United States Marine Corps. NRaD (then the Naval Ocean Systems Center (NOSC)) was the principle development agent on the system. GATERS consisted of a land-based, [Tele-Operated Vehicle \(TOV\)](#) and the [Airborne Remotely Operated Device \(AROD\)](#). The TOV was developed to perform remote reconnaissance/surveillance with direct fire and target designation/ranging capabilities. The TOV was based on a High-Mobility-Multi-Wheeled-Vehicle (HMMWV) platform [2] for which AROD provided airborne reconnaissance and surveillance. Experience with the TOV demonstrated the value of remotely operated reconnaissance systems and also demonstrated that a full time operator and high-bandwidth data-link is required for effective mobility. The TOV utilized a fiber-optic communications link to provide the required bandwidth in non-line-of-sight situations. The military users did not want to be encumbered with the fiber-optic tethers and preferred that one operator be able to supervise several remote systems.

The AROD, [figure 1](#), was a ducted fan VTOL air vehicle that could easily translate through the air and provide aerial surveillance. The AROD was controlled from a portable ground control station over a fiber-optic data-link, with a radio control link as a back up. AROD had limited flight endurance and payload capabilities.

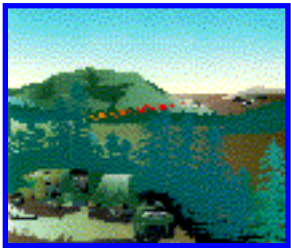
The AMGSSS concept marries the rapid mobility and low-data-rate control aspects of VTOL platforms with the long endurance surveillance capabilities of the unmanned ground vehicles.

AMGSSS PROGRAM

The AMGSSS program has been managed by the Physical Security Equipment Management Office (PSEMO), Ft. Belvoir, MD and sponsored by the Office of the Undersecretary of Defense (Acquisition, Tactical Systems/Land Systems). NRaD is supporting PSEMO as the program technical direction and development agent. The system was originally envisioned as supporting tactical security and force protection requirements. Recent interest by the US Army Dismounted Battlespace Battle Laboratory in use of the system in forward operations has led OSD to transfer management of the program to the Unmanned Ground Vehicle / Systems - Joint Program Office (UGV/S-JPO), Huntsville AL. UGV/S-JPO has cognizance over robotic system development for tactical applications.

OPERATIONAL CONCEPT

AMGSSS will support light and heavy early-entry forces with a rapidly deployable, highly mobile sensor system that provides extended range surveillance, detection and identification for force protection and tactical security throughout the battlespace. AMGSSS will give combat, combat-support, and combat-service-support battalion/company/combat team commanders near-real-time situational awareness. It will expand the areas of the commander's influence, reducing hazards to the soldier, and provide early warning and assessment of enemy threats [3].



[Figure 2](#) AMGSSS System Operation

The system, [figure 2](#), consists of three air-mobile, remote ground sensor units, a HMMWV mounted base station and a 3/4-ton trailer for ground transport of the Air Mobile Platforms (AMPs). The trailer will be towed by the HMMWV. The AMPs are small (less than 300 lb and 6 ft diameter) units that transport the sensor payload to the operational sites. The units do not perform aerial observation, but simply move the sensors from one ground location to another where they perform extended observation. AMGSSS will allow the field commander to quickly extend his information gathering perimeter out 10 kilometers. The three platforms can be deployed as a barrier to detect intrusions, or deployed independently to monitor assets, critical routes, or choke points. The sensors provide long-term surveillance without putting personnel at undue risk. The unit's rapid mobility and insensitivity to intervening terrain allow it to be quickly relocated to operationally relevant locations if the threat area moves.

The AMGSSS system will be operated by three military personnel. Upon arriving at the deployment site two soldiers will off load the AMPs from their trailer while the third, using the mission planner and the operational orders, locates the observation sites for AMP deployment. Consideration in selection of sites must include field of view for the sensors, terrain compatibility for landing, and near-line-of-sight with the base station for communications. The coordinates of the selected sites and required transit waypoints and altitudes would then be down loaded to the platforms.

After check out at the launch site each AMP will autonomously fly to its designated surveillance site. When the platform reaches the specified landing coordinates it will transmit an image of the terrain at the site for the operator to make a landing decision. Once the site is determined to be suitable, the operator will give the command and the unit then lands itself. Depending on terrain type and quality of

the information available to the operator the platform may have to send several images as it descends. The high level supervisory control capabilities and three-dimensional mobility allowed by the VTOL platform are ideally suited to this concept. If (during landing) there is loss of communications detected on the platform (due possibly to intervening terrain) the platform will simply elevate until communication is re-established to be directed to an alternate observation location.

The three AMPs will be deployed sequentially up to 10 km in less than 30 minutes each. Once landed the platform will power down and the sensor suite will go through a set-up sequence to provide sensor coverage of the region of interest. The sensor payload will consist of a daylight imaging camera, a forward looking infrared (FLIR) camera, and an acoustic sensor unit for self protection and imager cueing. Sensor processing will be performed on the platform to detect significant motion and/or acoustic signatures before alerting the operator. The portion of the image containing the potential target will be sent to the operator and displayed within the corresponding image stored in the operator's work station. Each AMP can be repositioned at least one time during its mission. Upon completion of the mission the operator will command the remote platform to restart, take off, rise vertically to its transit altitude, and return to the base station.

Communication between the AMPs and the base station will be over a tactical radio based data-link. The control and communication architecture will support use of modular mission packages such as communications relay, barrier/minefield detection, and nuclear/biological/chemical agent detection.

SYSTEM DESCRIPTION

The AMGSSS is comprised of two physically independent portions; the air-mobile portion and the ground-mobile portion. This section describes the prototype system design based on the trade-off studies performed to date.

Air Mobile Platform



[Figure 3](#) Air Mobile Platform

The air mobile platform is the mobility system that transports the sensors and communications payload from one operational site to the next. The current system design is based on the Sikorsky Cypher vehicle (a ducted fan, vertical-take-off-and-landing, unmanned aircraft) with a sensor pod mounted on top as shown in [figure 3](#). Projected weight of the mission-ready AMP is 270 lb, including the 60 lb mission

payload and fuel. Sufficient energy will be available to operate the sensors in surveillance mode for 12 hours and to restart the engine twice. Weight and power estimates are based on commercially available hardware, modified in some cases for the AMGSSS application. The AMP will carry sufficient fuel for a 30 km transit and three takeoff and landings.

Mission Payload

The mission payload consists of the sensor suite, onboard controller, communications, and battery power pack. The AMP serves as the transport platform for the mission package. All communication between the platform and the control station passes through the mission payload.

• Sensor Suite

The sensor suite is comprised of two subsystems; the landing sensors and the mission sensors. The landing sensors provide information to the operator on the suitability of the selected landing site in terms of slope, vegetation, and roughness. The present approach is to use imagery from downward-pointing cameras that is transmitted to the operator for landing site assessment. Photogrametric and laser scanning techniques are being considered for slope and roughness assessment.

The mission sensor payload includes a daylight video camera, a forward-looking infrared (FLIR) camera, a laser range finder, and an acoustic sensor for queuing to target presence and location. The video and thermal imagers are mounted on a pan-and-tilt unit for scanning the optical sensors over the area of interest.

• Onboard Controller

The onboard controller coordinates communications, image processing, sensor control, and commands to the platform flight management unit. Image processing is handled by an image processing card within the controller. Several technologies are under evaluation for image processing and data compression. AMP navigation is based on the differential global positioning system (GPS) capability in the Cypher.

• Communications

The communications subsystem transmits commands from the CDC to the AMP in the air and on the ground at its remote site. It also transmits compressed surveillance data (including FLIR or TV images) and status from the AMP to the CDC. Single Channel Ground and Airborne Radio System (SINCGARS) interoperable radios are being used.

• Batteries

Silver-zinc battery technology has been selected for the prototype system since it provides high energy

density, is readily available, and has known characteristics, although this is not the technology that would be used in an operational system. The secondary battery industry, which is being driven by the electric transportation and portable consumer electronics industries, is making a substantial investment in battery technology. We closely monitor the state of the art and will utilize the best available technology when the system design is finalized. Promising technologies include: nickel metal hydride, lithium-ion, and zinc-air.

Control-Display Center (CDC)

The operator interface is based on work station and graphical user interface technology and will be housed in a HMMWV equipment shelter. One operator will control and monitor the three AMPs. An alert will be given when there are images or sensor information coming in from the platform that require evaluation. The operator will have the option at any time of taking control of the sensors on any AMP and obtaining images of the surroundings. The CDC will also house a GPS unit to determine it's position, and communications equipment for connectivity to higher echelons.

The CDC will include an automated mission planner to support the operator in selecting the landing sites for the AMPs. Considerations in selecting observation sites include: sensor coverage of the mission area, terrain suitability for landing, and communications to the CDC. The mission planner will be based on digital-terrain-database technology and supporting algorithms to aid in site selection.

PROGRAM STATUS

Investigation of the AMGSSS concept was begun in FY 92. A preliminary system design has been developed and trade studies have been performed to select subsystem components. Evaluation of the capabilities of the platform and mission payload are underway. A draft Mission Needs Statement (MNS) has been prepared by the Dismounted Battlespace Laboratory, Ft. Benning, GA and is in the Army review and comment cycle. The following paragraphs summarize the accomplishments under each major subsystem area.

Air Mobile Platform

The Air Mobile Platform is the key component of the system. Our first objective was to determine the state of the art in small ducted-fan VTOL technology through demonstrations. A three-phase Broad Agency Announcement (BAA) was advertised in FY 93. Under Phase One the participants were asked to demonstrate their existing ducted-fan VTOL technology and to develop a preliminary design showing how it would support the AMGSSS concept. In Phase Two the most promising of the approaches were selected for evaluation against AMGSSS-specific requirements. These included: remote takeoff and landing, landing on slopes, autonomous flight, payload capacity, limited flight quality testing, and

development of an AMGSSS-specific platform design. Phase Three of the contract will deliver three prototype air-mobile platforms with an integrated mission payload.



[Figure 4](#) Sikorsky Cypher platform

On Phase One of the BAA, nine companies submitted proposals and three were selected. From the three the Sikorsky Cypher vehicle was chosen to proceed into Phase Two as it was the most mature of the technologies evaluated and funding was limited. Cypher, [figure 4](#), was developed under Sikorsky corporate funding [4]. The program has contracted with Sikorsky for test and evaluation of Cypher. Phase Two testing has extended over the past two years and has demonstrated the following capabilities in the platform:

- Fully autonomous takeoff and landing.
- Capable of landing on slopes to 15 degrees with indications that greater slopes were possible.
- Supervised autonomous flight control and navigation including, hover hold, position hold, altitude hold, velocity hold, and "return home".

Critical capabilities yet to be demonstrated include:

- Engine quieting.
- Heavy-fuel-capable engine.
- Stable flight in AMGSSS configuration, e.g., simulated sensor pod mounted.

Mission Payload Prototype

In FY 95 NRaD undertook the development of a Mission Payload Prototype (MPP) consists of two units analogous to the two components of the AMGSSS, i.e., the CDC and the AMP. The MPP remote unit is composed of the video camera, FLIR, laser range finder, subsystem controller, pan-and-tilt unit, and communications subsystems proposed for the AMGSSS prototype. The command unit contains a communications subsystem and lap-top-computer-based operator interface. Figure 5 provides a block diagram of the MPP. The objective of the MPP is to explore the integration issues of the payload, communications, and the operator interface. It will also provide a platform on which to test various data

compression and image processing hardware. The MPP will allow early interaction with the user community on how they would use the information available from the remote platforms and evaluation of operator interface, and communications issues.

The MPP has been breadboarded and run through preliminary debugging and demonstration trials. Racal PRC-139 tactical band radios are being used for communications. A PC-card-version of the Tactical Communications Interface Module (TCIM) is used to interface the computers with the radios. The data throughput with error correction and standard military protocols is on the order of 4000 to 8000 bits per second.

As an initial evaluation of the non-line-of-sight communications performance the remote portion of the MPP breadboard was mounted in a HMMWV. Images were collected and transmitted from the HMMWV as it was driven around our facility on Point Loma, San Diego. SINCGARS radios were used as the small PRC units had not yet been received. Images from the moving vehicle on one side of the Point were received reliably at our Bayside facility on the opposite side. 256-by-256 pixel images were transmitted at a rate of three frames per minute with the four kilobit data rate.

Sensors for the MPP are those that are being proposed for the AMGSSS prototype,. selected primarily based on performance, weight, and power consumption. The FLIR is the Inframetrics Infracam. Three days and one night of testing the Infracam with a 100 mm lens at Camp Pendleton, CA showed its sensitivity to be adequate to discern moving targets at up to 5 km. A Cohu 2122 black and white video camera with Canon J10X10 (10 to 100 mm) zoom lens with a times two range extender was selected for daytime imagery. We propose to use the Contraves laser range finder that is based on erbium-glass technology and weighs 0.6 kg but, selected the Riegl Lasertape as a short range (1 km), low-cost, interim solution.

It was difficult to find an off-the-shelf pan/tilt that could meet our weight, payload, speed, and position-feedback requirements. The closest we came was with the TRC Zebra unit, which has a limited weight capacity. We analyzed the motor design and found it adequate, then tested it with a pair of 5 lb. weights mounted to simulate the anticipated rotational inertia. We found that performance is adequate if speeds are kept to less than 100 degrees per second.

Three acoustic detection systems have been qualitatively evaluated in the field. The systems showed promise but none met all of our criteria. At least one will be demonstrated with the MPP.

The MPP image processor (IP) performs the image processing, including source (FLIR/TV) selection, frame grabbing, image contrast enhancement, video motion detection, and image/video compression. The IP will serve as a test bed for applications related to remote day/night video surveillance using small low-power, embedded-image-processing hardware.

Three variations of the IP hardware will be evaluated: (1) a X86 central processor unit (CPU) and frame grabber, (2) a X86 CPU and digital signal processor (DSP) frame grabber, and (3) a X86 CPU and

application specific integrated circuit (ASIC) vision processor. The image processing algorithms are hosted differently amongst these three configurations. Configurations (1) & (2) are PC/104-based, while (3) is ISA-based. Configuration (3) provides the highest performance capability. As an embeddable image processing test bed, the IP will be used to investigate and develop robust algorithms for remote video surveillance applications. These algorithms include: error resilient image/video compression for transmission over noisy radio channels; camera image stabilization for image jitter induced by wind; better compression techniques for low bandwidth channels and directed motion detection for low signal-to-noise video sequences.

A portable operator control station has been developed for the MPP using software running under the Windows operating system. The use of network communications allows the program to control the remote sensor package and display the remote sensor status as well as images transmitted in real time. Special attention is being given to creating an operator interface that is simple and intuitive to use. The operator will be able to point and click with a mouse to do most operations necessary to control the remote unit.

Summary

Progress to date on the AMGSSS project supports feasibility of the concept. The platform has demonstrated that it is capable of take off, transit, and landing under supervisory control. Analysis and testing have demonstrated that in beyond-line-of-sight situations data rates are available over tactical military radios that will support operation of the remote platforms. Analysis and testing have also demonstrated that a payload can be provided that meets the weight and volume capabilities of the Cypher vehicle. The MPP will be completed in August after which we will begin testing at our laboratory and at several user locations.

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Upward links:



[MSSMP](#) (formerly AMGSSS)



[Robotics at Space and Naval Warfare Systems Center, San Diego](#)

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